8-23-2017

Market and Welfare Effects of Renewable Portfolio Standards in United States Electricity Markets

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AGRICULTURAL ECONOMICS

August 23, 2017

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Cornhusker Economics

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Market Report	Year Ago	4 Wks Ago	8-18-17
Livestock and Products, Weekly Average			
Nebraska Slaughter Steers, 35-65% Choice, Live Weight.	117.50	120.00	*
Nebraska Feeder Steers, Med. & Large Frame, 550-600 lb.	*	*	160.70
Nebraska Feeder Steers, Med. & Large Frame 750-800 lb.	151.38	171.94	158.25
Choice Boxed Beef, 600-750 lb. Carcass.	201.24	207.88	197.06
Western Corn Belt Base Hog Price Carcass, Negotiated	63.38	82.89	71.62
Pork Carcass Cutout, 185 lb. Carcass 51-52% Lean.	73.71	102.94	91.07
Slaughter Lambs, wooled and shorn, 135-165 lb. National.	162.81	182.28	175.55
National Carcass Lamb Cutout FOB.	359.00	431.08	416.66
Crops, Daily Spot Prices			
Wheat, No. 1, H.W. Imperial, bu.	3.02	3.83	3.03
Corn, No. 2, Yellow **Columbus**, bu.	2.99	3.41	3.22
Soybeans, No. 1, Yellow **Columbus,** bu.	9.67	9.22	8.49
Grain Sorghum, No.2, Yellow Dorchester, cwt.	4.63	5.75	5.38
Oats, No. 2, Heavy Minneapolis, Mn, bu.	2.30	3.26	2.89
Feed			
Alfalfa, Large Square Bales, Good to Premium, RFV 160-185 Northeast Nebraska, ton.	158.75	165.00	*
Alfalfa, Large Rounds, Good Platte Valley, ton.	72.50	82.50	82.50
Grass Hay, Large Rounds, Good Nebraska, ton.	70.00	80.00	85.00
Dried Distillers Grains, 10% Moisture Nebraska Average.	122.50	105.00	107.00
Wet Distillers Grains, 65-70% Moisture Nebraska Average.	33.25	39.50	39.00

*** No Market**

Rising energy prices, dependence on foreign oil supplies, and alarming consequences of global warming have prompted governments worldwide to initiate green energy policies that can motivate a shift away from fossil fuels and toward renewables for electricity generation. Recognizing the fact that around 40 percent of carbon dioxide (CO_2) emissions in the United States come from fossil fuel combustion in the electricity sector, several policies have been adopted across states for reducing carbon emissions and stimulating renewable energy development. One of the innovative policy instruments that stands out due to widespread adoption by states since the late 1990s is the Renewable Portfolio Standard (RPS). According to this policy, the electricity providers serving the end users in a state are required to procure green energy (such as wind, solar, biomass, or geothermal energy) for a portion of their electricity supplies.

To date, RPS has been a state-mandated program in the United States with Iowa and Minnesota being the first states to place minimum requirements for renewable energy on their electricity providers in 1983 and 1994, respectively. Since then, the policy has gained significant momentum and the adoption rate continued to increase with time. As of August 2016, 29 states, Washington DC, and 3 territories have adopted this policy while 8 other states and 1 other territory have renewable portfolio goals (DSIRE, 2016). However, due to state-specific patterns of regulatory structure and other inherent characteristics such as natural resource endowments, generation potential of green energy, and political interest, there is considerable variation among the states in RPS goals, coverage, and in-state requirements.

In addition to an array of state RPS programs already in place, efforts have been made to advance a national RPS policy. Several bills with provisions for federal renewable electricity standards have been proposed since 2002. However, these bills have, so far, failed to become a law. While the increased costs associated with mandating green energy appear to be a key deterrent of a national RPS, in addition to the benefits mentioned earlier, proponents of the policy argue the existence of, in some cases, significant consumer support that could ameliorate at least part of these costs. With the growing trend on RPS adoption across the country, debates on the implementation of federal RPS, and the potential for states to achieve the recently enacted Environmental Protection Agency's Clean Power Plan (CPP)[1] goals using RPS, the resurgence in research attention devoted to this policy has been anything but surprising.

Some recent studies have evaluated the economic effects of the RPS introduction at the national level but none account for the empirically relevant differences in consumer preferences for different types of energy, the potential for imperfect competition among the electricity suppliers, and the links and interactions between the markets for regular and green energy. Explicitly accounting for the links and interactions between these markets is particularly important due to the coexistence of mandate-driven *compliance* markets (where regular power[2] containing a portion of renewables is sold to the end users) with *voluntary* markets (where consumers purchase green power from their electric suppliers on a voluntary basis)[3]. While the presence of these voluntary green markets demonstrates a consumer support for renewables and can contribute to the passage of RPS, stringent RPS requirements can increase competition for renewable energy generation between the two markets (Bird and Lokey, 2007). In this context, explicitly considering the links and interactions of these markets is crucial in better understanding the system-wide effects of RPS.

[1] The new Clean Power Plan, proposed by the EPA in 2014 and finalized in 2015, is the first federal policy to enact state-specific carbon emission limits. However, the future of the CPP is uncertain under the current administration.

[2] Regular power is defined here as the power generated from fossil fuels such as coal and natural gas, nuclear energy, and hydropower. With the implementation of RPS, the fuel mix used to generate regular power contains a mandated percent of renewables. Green power is the power generated from non-hydro renewable sources such as wind, solar, biomass, or geothermal.

[3] As of 2011, over 860 utilities that cover more than half of U.S. electricity consumers offer voluntary green pricing programs. (Heeter, Armstrong, and Bird, 2012).

The objective of a recently published paper (Bhattacharya, Giannakas, and Schoengold, 2017) is to determine the system-wide market and welfare effects of the introduction of RPS in United States electricity markets. To analyze the economic effects of RPS, our analysis develops a general theoretical framework of heterogeneous consumers and imperfectly competitive energy suppliers that takes into account both the supply and demand effects of RPS which include increased costs (i.e., *cost effect*) and a higher consumer valuation (i.e., *utility effect*) for regular power. Our work incorporates the possibility that green energy for RPS (compliance markets) may be more expensive than voluntary markets due to additional restrictions. It also incorporates the possibility that mandated RPS may lead to congestion in procuring green energy, which will increase the cost of current voluntary green power programs. While our analysis focuses on the market and welfare impacts of the introduction of an RPS policy, the analysis (and results) are directly relevant to cases where states with RPS increase the mandated share of renewable energy in the regular power mix.

Our analytical results show the following:

Result 1: While the introduction of RPS increases the price of regular power, the effects of the policy on regular and green power quantities and green power price depend on the relative magnitude of the cost and utility effects, the strength of consumer preference for green power, the supplier costs before RPS, and the degree of competition among suppliers in the two power markets.

Result 2: The introduction of RPS can reduce the total quantity of green power used in electricity production. This adverse policy impact will occur when the inclusion of a relatively small share of renewables in the regular power mix (mandated by RPS) generates a significant consumer response (strong utility effect) and/or a small increase in the costs of regular power (weak cost effect).

We use a simulation based on estimated costs of electricity generating facilities, fuel costs, and the value consumers place on green energy to determine the most likely effects of adopting RPS policies by those states that do not currently have one. We compare outcomes under constant and increasing costs of green power, and we evaluate two sources of green energy (wind and solar). The percent of renewables mandated is generally between 10 and 30 percent (DSIRE 2016),), so we use 20 percent for the simulation analy-

sis. Our analysis also incorporates a small amount of market power in both the green and regular electricity markets.

Due to the relatively high cost, it is unlikely that RPS requirements will be met using solar energy. Thus, we focus on the results that use wind power to meet the mandate in our discussion. We find that the post-RPS price of regular power increases by 0.21 to 0.5 cents per kWh (approximately 5 to 10 percent) when the mandate is achieved using wind energy. When green power costs are unchanged after RPS, we find an increase of 2 to 6 percent in the total amount of renewable energy used. However, if green power costs increase under RPS due to congestion, total renewable energy use could decrease by up to 10 percent. The reason for the decrease in total renewable energy use under certain scenarios is that an increased cost for voluntary green energy may lead to some consumers shifting from the green to the regular market.

Our results show that the most likely scenario in areas with no congestion in renewable energy availability is an increase in the quantity of green power and an increase in the price of regular power. Under this scenario, there is an increase in welfare for green consumers. This is consistent with many consumers not supporting RPS policies. With this outcome, firm profits in both markets can decrease, a result that is consistent with a lack of industry support for RPS. Thus, under plausible scenarios, RPS policies can be successful in achieving the primary goal of the policy (i.e., increasing the use of renewable and decreasing the use of conventional energy sources). Areas that are likely to have congestion for renewable energy sources are more likely to observe an increase in consumer welfare because of the utility effect and an increase in the profit of regular firms. Thus, it is likely that RPS policies will have considerable political support in these cases. However, results show that the effect may actually be a net decrease in renewable energy, which is contrary to the primary goal of RPS. In such cases, there may be real economic benefits of RPS but little (if any) environmental benefits.

Our study also shows that the policy design can play a key role in determining the effects of the policy when the costs and consumer attitudes vary, as they normally do, across the different alternatives. For instance, the cost effect of RPS requirements may be lower in a non-RPS state with plentiful wind energy (e.g., Nebraska) than in one with limited sources of wind energy (e.g., West Virginia). In the first case, underutilized wind energy capacity may result in no change in the cost of green power after RPS while the second case is more likely to lead to an increase in the cost of green power. The results can provide insights on the political economy of RPS and the positions held by different groups in policy negotiations. Obviously, whether a certain state falls under a particular scenario or not is an empirical question worthy of further research.

This article is based upon research partially supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award number 2012 -70002-19387. The authors would also like to thank the University of Nebraska's Agricultural Research Division for the financial support of this work.

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